Glacier Retreat at Glacier National Park

At Glacier National Park in Montana (Figure 1), the U.S. Geological Survey has been documenting the retreat of glaciers for two decades through the "Climate Change in Mountain Ecosystems" project led by Dr. Dan Fagre. The mid-latitude Rocky Mountain glaciers found there are monitored using a combination of techniques such as remote sensing, aerial and ground-based photography, and GPS-assisted field surveys. A recent New York Times article "Climate Change Threatens to Strip the Identity of Glacier National Park" highlights some of Fagre's major findings.

Figure 1. Dan Fagre PhD, Project Chief for Climate Change in Mountain Ecosystems project conducting field research on Sperry Glacier, Glacier National Park, Montana

Figure 2. USGS field scientist using a gigapixel camera as part of a repeat photography project to document changes in glaciers over time.

Since the park was established in 1910, some glaciers within the park have disappeared entirely. Furthermore, the current rate of ice disappearance is greater than last century. To help park managers better understand the drivers of ice loss, intensive studies on Sperry Glacier were initiated in 2005. In addition to installing a remote weather station at Sperry Glacier to record vital climate information, USGS researchers also trekked to dozens of the remaining glaciers to maintain the USGS archive of repeat historic photographs, some taken as early as 1887 (Figure 2).

Glacier monitoring at Glacier National Park is part of the broader USGS Benchmark Glacier program which also carefully observes glaciers in Alaska and Washington. These long-term studies measure the ice mass of a glacier, not just the amount of terrain it covers, and allow for standardized comparisons with other glaciers around the world. In collaboration with other scientists, USGS researchers are studying Glacier National Park as a representative mountain ecosystem to examine the myriad and connected ways that climatic changes alter the form and function of high-elevation environments (Figure 3). The team has monitored snow cover and alpine climate for over 20 years to ascertain long-term trends and to see how shifts in climate conditions affect other mountain ecosystems and species that depend upon them. Examples of specific research topics include amphibians and UV radiation, forest dynamics, wildfire frequency, and paleoclimates. Tree-ring studies, for instance, show a reduction in snowpack occurring over the past 50 years that is not seen in the last 1,000 years. Reduced snowpack and disappearing glaciers result in alpine stream temperature increases that negatively affect habitats for aquatic insects adapted to the cold temperatures. These subtly associated changes can cascade throughout the mountain ecosystem in ways that are still being determined.

In recent years, the focus of the project at Glacier National Park has shifted to the alpine areas where change is less mediated by biological interactions and is more directly related to climate. The alpine focus is on glaciers, snow, alpine climatology, avalanches, and alpine vegetation change. Alpine vegetation endures in the harshest climates in mountains and is expected to show early responses to climate change (Figure 4). Avalanches provide ecological benefits for the mountain landscape by keeping open corridors in the forests. These corridors, the avalanche paths, have different and diverse vegetation from the surrounding forests that is utilized by many mountain wildlife species. The USGS team has described the role of snow avalanches by determining natural avalanche frequencies and extents, characterizing wet snow avalanches, determining the meteorological triggers for avalanche release, and monitoring post-avalanche vegetation changes.

Figure 3. Field botanist documenting changes in alpine vegetation near a mountain summit in Glacier National Park, Montana

Figure 4. Alpine vegetation sheltered from high winds by a rock outcrop

The USGS studies indicate that the primary drivers of glacial decline are changes in precipitation patterns coupled with higher mean temperature, a combination of climate-driven factors that affects park flora and fauna as well as the rates of glacial melt. Correspondingly, Fagre's team has observed changes in alpine vegetation over the past two decades and has described patterns and drivers of species turnover and abundance. By coordinating their research with global networks of mountain vegetation scientists investigating large-scale patterns of response to climate change, the team found that the species turnover in Glacier National Park is higher than comparable European sites. With the variety of different research studies focused on the alpine area of Glacier National Park, climate-based connections are becoming clearer but a comprehensive synthesis will take more time.

Dan Fagre and Glacier National Park Superintendent Jeff Mow shared their perspectives at the International Union for Conservation of Nature World Parks Congress, held in Sydney, Australia this past fall. The World Parks Congress is a decadal event that celebrates protected areas, addresses global challenges and opportunities, and establishes standards to ensure effective park management and protection.